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WATER QUANTITY AND QUALITY OF THE SUN RIVER FROM GIBSON DAM TO VAUGHN, 1973-1974*

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ABSTRACT

Water quantity and quality of the Sun River from Gibson Dam to Vaughn was studied during 1973 and 1974. A total of 14 stations on the Sun River and 16 on tributary or irrigation returns to the Sun River were monitered for flow, water temperature, turbidity and total dissolved solids. In addition, flow measurements were determined for 12 irrigation diversions from the Sun River.

INTRODUCTION

Information is limited on quantity and quality of water in the Sun River. Since these attributes are important to the aquatic resource, a study of the Sun River from Gibson Dam to Vaughn was conducted from April to September, 1973 and from April to October, 1974. Objectives of the study were to measure water quantity and quality in the Sun River, in diversions and waste water tributaries to the River. Recommendations on flows needed to preserve the river fishery based on fish population data were to be made. The river, as well as the tributaries and irrigation returns were monitered for flow, temperature, turbidity and total dissolved solids. Flows into irrigation diversions were measured.

The years studied presented somewhat of a contrast; 1973 was a low water year and 1974 experienced average or above runoff from mountain snowpack. This explains why turbidities were comparatively low in 1973 and higher during runoff in 1974.

Access problem areas were encountered at several locations along the river. Consequently, these areas were not included in the study.

A total of 42 stations were monitered: 14 on the Sun River; 12 on irrigation diversions from the Sun River; and 16 on tributary or irrigation returns to the Sun River. The figures given for various measurements in this report are ranges. The field data is on file in the Choteau field office.

DESCRIPTION OF STUDY AREA

The headwaters of the Sun River lie in the Bob Marshall Wilderness Area, a mountainous region east of the Continental Divide and south of Glacier National Park. Upon emerging from the mountains, the Sun River meanders for nearly 90 miles between rolling grass-covered foothills and farmland to its confluence with the Missouri River at Great Falls.

Two impoundments formed by Gibson Dam and Diversion Dam are located on the river before it emerges from the mountains. Flows of the Sun River are controlled by Gibson Dam and are mostly related to releases for irrigation. Pishkun and Willow Creek Reservoirs, two off-stream irrigation impoundments, receive water via canals from Diversion Dam.

A number of temporary irrigation diversions are found throughout the course of the Sun River. Approximately 110,000 acres of land are irrigated by Sun River waters. A six year (1967-1973) average discharge of the river below Diversion Dam is 397 cfs.

METHODS

Flow measurements were obtained from USGS records, Irrigation District records or were calculated using a modification of Embody's float method as described by Engstrom-Heg (1971). Water samples were analyzed for turbidity and conductivity with the aid of a Hellige Turbidimeter and Hach kit. Turbidities are expressed in ppm SiO_2 for 1973 and JTU (Jackson Turbidity Units) for 1974. No conversion factor is known to compare the two units. Total dissolved solids were recorded for 1974 only. Temperatures were recorded instantaneously with a pocket thermometer and on recording thermographs of 7-day and 30-day duration. Photographs were taken from the air and on the ground to document possible problem areas. Observations were made whenever time permitted and attempts were made to sample all stations within a two day time period.

DISCUSSION OF RESULTS

Table 1 presents a listing of the sample stations on the Sun River, Diversions and Tributary or Irrigation Returns. A series of photos depicting various situations in the study area are found in Appendix I.

Table 1. Number and name of stations on the Sun River (USGS = 0), Diversions, and Tributary or Irrigation Returns. (Stations numbered in order from upstream to downstream and correspond to Figures 1, 6 and 7 and Tables 2-4).

Sun River			Diversions		Trib. or Irrig. Returns	
Sta.		Name	Sta.	Name	Sta.	Name
1		below Gibson Dam	2	Pishkun Res.	5	Arnold Coulee
4	(0)	below Diversion Dam	3	Willow Cr. Res.	6	Split Rock L. Drain
10		above Willow Cr. Res. Drain	7	Kilraven	11	Willow Cr. Res. Drain
13	(0)	below Willow Cr. Res. Drain	8	Warden	14	Elk Creek
15		above Spring Coulee Creek	9	Beecher	16	Spring Coulee Creek
17		at Company Diversion	12	Floweree	20	Dry Creek
21		above School Section Coulee	18	Company	22	School Section Coulee
24		at Fort Shaw Diversion	19	Alfalfa	26	Simms Creek
27	(0)	at Simms	23	Simpson	28	Big Coulee
32		at S.R. Valley Diversion	25	Fort Shaw	30	Drain west of Ft. Shaw
35		above Mill Coulee	29	Rocky Reef	31	Dobie Creek
37		below Mill Coulee	33	Sun R. Valley	34	Drain east of Ft. Shaw
39		above Muddy Creek			36	Mill Coulee
42		below Muddy Creek			38	Drain by Barsotti's
					40	Sun R. Valley Drain
					41	Muddy Creek

Sun River

The locations of 14 Sun River stations are presented in Figure 1 and the resulting data in Table 2. The following discussion pertains to stations where significant data was gathered or where changes in water conditions were noted.

Monthly mean flows of the Sun River below Diversion Dam are presented in Figure 2. Maximum and minimum flow extremes for the entire river occurred below Diversion Dam during both years of the study, and ranged from 20 to 562 cfs in 1973 and 7 to 6,990 cfs in 1974. Maximum readings are a result of spring runoff conditions while minimum readings relate to closing of Diversion Dam by the Greenfields Irrigation District to inspect the concrete structure of the dam. This occurred on April 18, 1973 and on April 25, 1974. Data for 1974 shows the river flow was progressively reduced from 33 cfs at 9:15 A.M. to seepage of 7 cfs at 3:30 P.M. (Photo 1). The reduced flow exposed stream bottom and insect life and stranded fish. Sculpins and young brown trout, rainbow trout and whitefish were observed stranded.

Continuous thermograph records at three locations on the river show that maximum water temperatures occurred during late July and early August (Figures 3-5). A gradual increase in river temperatures was noticed progressing downstream. The increase is considered normal since temperatures at mouths of most tributaries and irrigation returns are similar to the river. The exception is the Willow Creek Reservoir Drain that increased river temperatures slightly.

Turbidity of the Sun River increases gradually downstream, with maximum readings occurring during spring runoff. In 1973, turbidities increased to 38 ppm below Gibson Dam during August when irrigation drawdown created near river conditions in Gibson Reservoir (Photo 2). Mud banks sloughed into the river, and wind and wave action on exposed mud shorelines caused siltation in the river below the dam. A maximum turbidity of 69 ppm was measured in 1973 at the lowermost river station. This was caused by turbid flows from Mill Coulee and Muddy Creek which are affected by irrigation waste and seepage water throughout the irrigation season. A maximum turbidity of 750 JTU was measured in the Sun River in 1974 and again is the result of the Mill Coulee and Muddy Creek returns. Turbidity of the other returns are generally higher than the Sun River but had little effect on the river at observed flows. Turbidity of the Sun River could be affected to a greater extent if the return flows were increased or if the river flows were decreased, thus reducing the dilution factor. Gravel pits are located in this same area and may also contribute to the turbidity of the river.

Total dissolved solids in the Sun River gradually increased downstream and ranged from 90 ppm below Diversion Dam to 555 ppm at the lowermost station below Muddy Creek.

Attempts were made to estimate trout populations in the river, however, inadequate samples of fish were captured for an evaluation of flows needed to preserve the fishery.

Figure 1. Sun River Sampling Stations, 1973-1974. (Refer to Table 1 for names of stations).

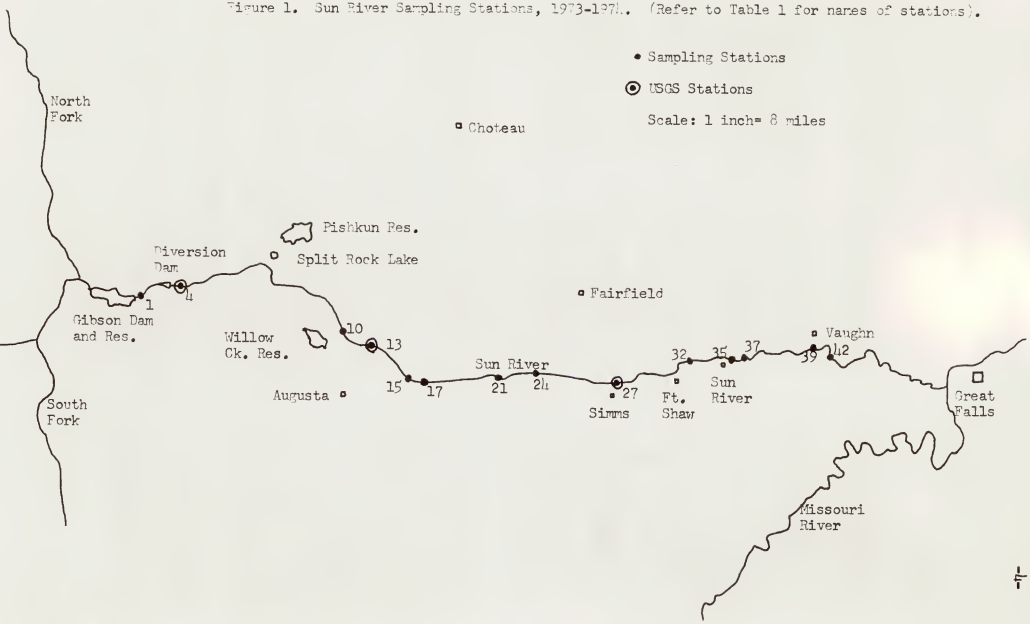
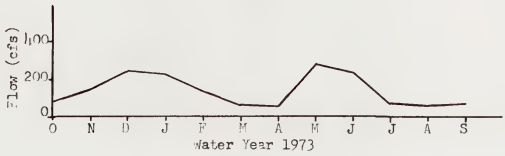


Table 2. Flow, turbidity, total dissolved solids (TDS) and temperature of Sun River stations, 1973-1974. (Showing ranges).

Sta.	Number of Observations 1973	1974	Flow (cfs) 1973	1974	Turbidity 1973(ppm)	1974(JTU)	TDS (ppm) 1974	Temperature °F. 1973	1974
1	8	0			6-38			56-61	
4	9	11	20-562*	7-6,990*	5-20	5-50	90-210	50-66**	46-61**
10	5	4			2- 8	8-65	110-155	60-72	48-59
13	5	8	38-409*	40-6,710*	7-10	5-73	110-220	63-69	49-63
15	0	7				5-85	110-245		48-64
17	0	3				8-75	120-175		55-56
21	6	7			3- 7	5-92	110-275	61-70	47-69
24	3	6			3- 6	5-95	120-290	51-77**	49-77**
27	0	10	39-400*	37-6,670*		5-118	120-300		46-73
32	5	5			3- 8	5-150	120-400	61-70	46-63
35	0	6				5-160	150-445	47-74**	44-77**
37	0	7				5-160	140-490		44-65
39	3	5			6-21	20-175	130-475	72-76	48-67
42	4	7			18-69	26-750	150-555	63-71	43-66

* USGS gage station records
** Continuous thermograph records



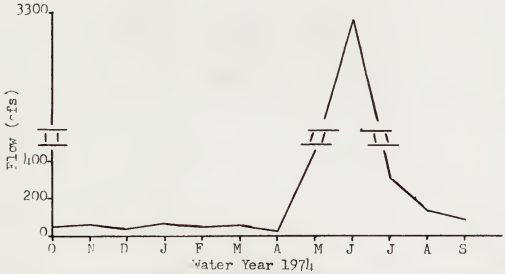


Figure 2. Monthly mean flow of Sun River below Diversion Dam for water years 1973-1974.

Figure 3. Maximum-minimum temperatures (5-day average) of Sun River below Diversion Dam, 1973-1974.

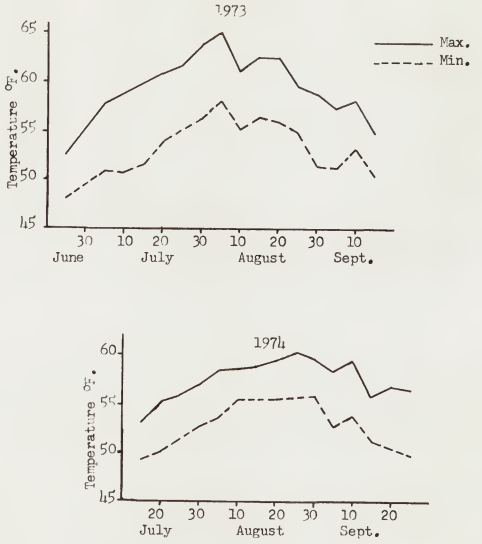


Figure 4. Maximum-minimum temperatures (5-day average) of Sun River at Fort Shaw Diversion, 1973-1974.

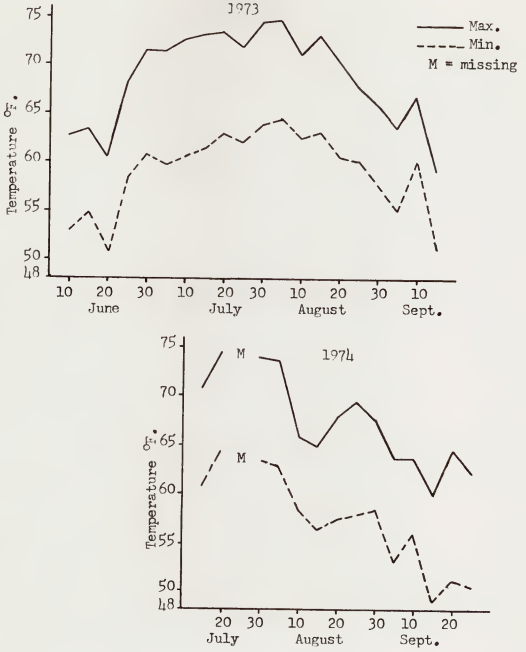


Figure 5. Maximum-minimum temperatures (5-day average) of Sun River at town of Sun River, 1973-1974.

Diversions

The locations of 12 irrigation diversion stations are presented in Figure 6 and the resulting data in Table 3. Discussion follows on the more important diversions.

Diversions from the Sun River varied in flow from 5 to 1,537 cfs. The Pishkun Reservoir Diversion is the largest diversion from the Sun River with a maximum designed capacity of 1,400 cfs. Maximum flow diverted was 1,473 cfs in 1973 and 1,537 in 1974. Other canals carrying more water than they were designed for were Rocky Reef Diversion (initial capacity of 25 cfs with 38 cfs measured in 1973) and the Sun River Valley Diversion (initial capacity of 75 cfs with 110 cfs measured in 1973 and 84 cfs measured in 1974). The Pishkun Diversion is under the control of the Bureau of Reclamation through the Greenfields Irrigation District and supplies water to Pishkun Reservoir. From this reservoir, canals supply water to the Fairfield Bench area. Excess and irrigation waste water from this irrigation network is returned via many drainages, with the majority accumulating in Muddy Creek, Mill Coulee, Big Coulee and School Section Coulee. Besides waste of excess water into the drainages mentioned above, large amounts of water are lost through evaporation and seepage. Greenfields Irrigation District personnel (personal communication) have stated there is up to a 50 percent loss of water due to evaporation and seepage in the Supply Canal from the Sun River to Pishkun Reservoir and a 50 percent loss in the Sunny Slope Canal from Pishkun Reservoir to the Fairfield Bench. A major portion of the seepage water probably is returned to the Sun River via percolation and so may be considered beneficial. However, if this water wouldn't have been diverted in the first place, river flows could have been maintained at higher levels.

The Willow Creek Reservoir Diversion is also under the control of the Bureau of Reclamation through the Greenfields Irrigation District. Water is diverted from the Sun River through the same structure as the Pishkun Diversion and water is stored in Willow Creek Reservoir. Water is released from the reservoir during low water months to maintain a flow in the Sun River when the majority of the flow is diverted to Pishkun Reservoir. Also, the Fort Shaw Irrigation District has a storage interest of 5,400 acre feet of water in the reservoir. This diversion canal goes through the Sun River Game Range and is causing serious bank erosion where the gradient of the canal drops abruptly. Much of the eroded material is carried downstream into Willow Creek Reservoir. The Bureau of Reclamation conducted a feasibility study during 1974 on possible corrective measures.

The Fort Shaw Diversion is under the administration of the Bureau of Reclamation through the Fort Shaw Irrigation District. Excess water from this system is returned to the Sun River via a drain west of Fort Shaw and Dobie Creek east of Fort Shaw. Other instances of water diverted and not used for irrigation were monitered. These included the Greenfields Project to several tributaries already mentioned and the Sun River Valley Canal into Muddy Creek. On several occasions, unused water ran straight through the Sun River Valley Canal to Muddy Creek at Vaughn. During 1973, excess flows at this point varied from 10 to 40 cfs and in 1974 from 16 to 48 cfs.

Figure 6. Diversion Sampling Stations, 1973-1974. (Refer to Table 1 for names of stations). Irrigation canals shown at point of diversion only.

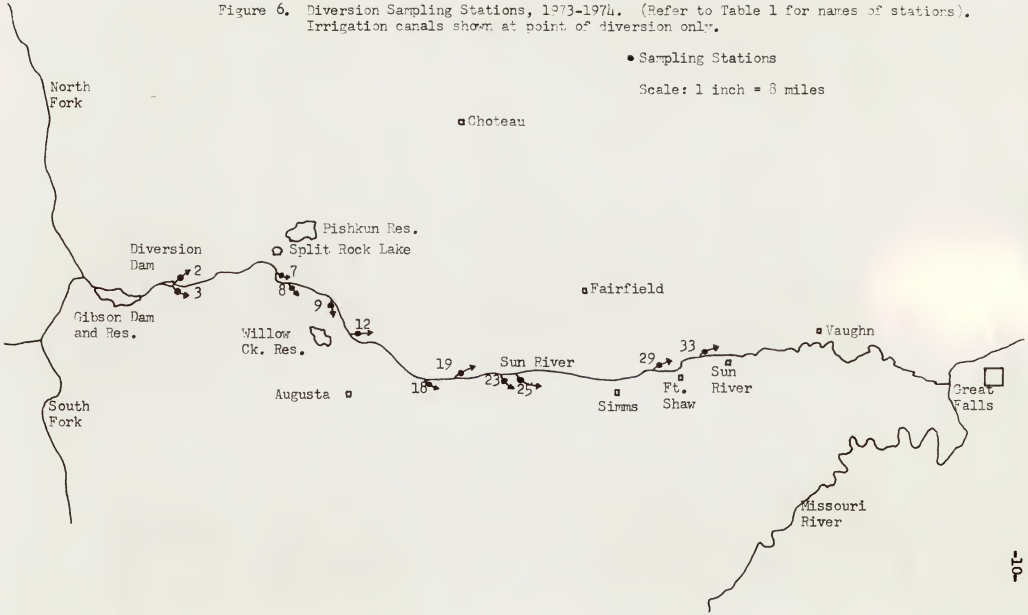


Table 3. Flows of Diversion stations, 1973-1974. (Showing ranges).

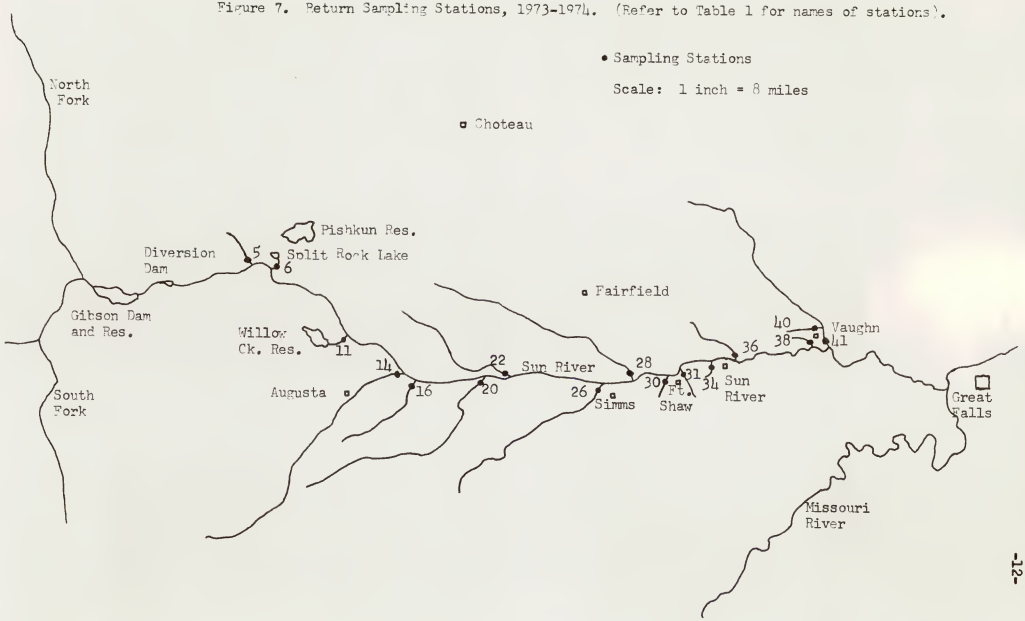
Station	Number of Observations 1973	1974	Flow (cfs) 1973	1974	Total Discharge (acre ft.)* 1973	1974
2	0	0	0-1,473*	136-1,537*	261,379	313,875
3	0	0	0- 160*	3- 185*	20,354	9,011
7	0	4		3- 22		
8	0	4		0- 8		
9	0	4		0- 30		
12	4	5	80(E)- 106	50(E)- 83		
18	0	4		20(E)- 58		
19	1	1	20(E)	20(E)		
23	0	3		5(E)-10(E)		
25	0	0	27- 296*	25- 296*	52,185	42,800
29	1	0	38			
33	4	5	90(E)- 110	57- 84		

(E) = Estimated flows
* From Irrigation District records

In 1973, dewatering of the Sun River was evident at three stations: below Diversion Dam (discussed under Sun River stations); below the Fort Shaw Diversion (Photo 3); and below the Rocky Reef Diversion (Photo 4). However, accretions bring up river flows a short distance downstream. Photo 5 depicts a more normal flow below the Rocky Reef Diversion.

Several diversion canals crossed irrigation return or tributary streams with little or no transfer of water. The Floweree Diversion Canal crosses over School Section Coulee near Golden Ridge with no transfer of water (Photo 6). In July of 1973, flows of 18 cfs and a turbidity of 7 ppm were measured in the Floweree Canal while measurements in School Section Coulee indicated flows of 29 cfs and turbidity of 36 ppm. Another example is the Alfalfa Diversion Canal and School Section Coulee joining together (Photo 7) downstream from the crossover of the Floweree Canal and School Section Coulee. Turbidity measurements were made twice in 1973 at the junction of the Alfalfa Canal and School Section Coulee. On June 28 and July 16, turbidity of the Alfalfa Canal was 2 and 9 ppm, respectively. Turbidity of School Section Coulee on the same dates was 95 and 30 ppm, respectively. A third example is the Sun River Valley Diversion Canal flowing beneath Mill Coulee near the town of Sun River (Photo 8). Some transfer of water is made from Mill Coulee into the Sun River Valley Canal at this point. Several turbidity samples were collected from these two waters during 1973. The Sun River Valley Canal varied from 2 to 5 ppm, while Mill Coulee ranged from 20 to 40 ppm. All three examples point to the fact that more clean water could be left in the Sun River if the taking of excess water was minimized and turbid tributary waters could be utilized for irrigation.

Figure 7. Return Sampling Stations, 1973-1974. (Refer to Table 1 for names of stations).



Bulldozer activity was evident at 7 of the 9 diversions checked. Photo 9 depicts the typical private and smaller diversions in which bulldozers are used every year to rebuild gravel and rock dikes, particularly after high water. Diversions in which bulldozer activity was evident include the Kilraven, Warden, Beecher, Floweree, Alfalfa, Simpson and Rocky Reef.

Tributary or Irrigation Returns

The locations of 16 tributary or irrigation return stations are presented in Figure 7 and the resulting data in Table 4. Items of significance are discussed below.

Flows of returns varied from no flow to a maximum of 730 cfs. Absence of flow in some returns relate to all of the water being used for irrigation (Split Rock Lake Drain, and Simms Creek) or the water shut off such as the Willow Creek Reservoir Drain. The maximum reading of 730 cfs was recorded in Muddy Creek following heavy rainfall and much of the flow is attributed to spillage of excess water from the Greenfields Irrigation Project. Maximum flows of most other returns also correspond to excess water from irrigation following rainstorms.

Table 4. Flow, turbidity, total dissolved solids (TDS) and temperature of Tributary or Irrigation Return stations, 1973-1974. (Showing ranges).

Station	Number of Observations 1973	1974	Flow (cfs) 1973	1974	Turbidity 1973(ppm)	1974(JTU)	TDS(ppm) 1974	Temperature °F.* 1973	1974
5	0	3		1(E)		3	310		
6	0	4		0					
11	6	5	0-170**	0- 75**	7-20			64-68	
14	0	5		3(E)- 88		2- 13	225-295		52-77
16	0	7		3(E)- 38		5- 42	260-380		53-65
20	0	5		5(E)		20- 95	240-630		50-73
22	6	7	31	5(E)-30(E)	4-21	22- 75	200-330	56-67	43-69
26	0	5		0-10(E)		12- 22	250-710		53-71
28	2	7		5(E)-40(E)	13-20	15- 135	350-2500	68-70	43-86
30	0	7		5(E)-39		6- 75	240-450		49-70
31	0	5		5(E)-58		10- 90	350-1250		47-66
34	7	4		5(E)-10(E)	6-30	43- 125	300-380	64-72	51-70
36	6	7	15	5-39	20-40	12- 170	310-745	63-74	41-63
38	1	3			18	45	525	80	65
40***	7	6	10- 40	16-48	3-14	15- 130	150-460	64-75	44-65
41	7	8	14-446****	19-730****	20-250	30-1000	230-700	62-69	41-73

(E) = Estimated flows
* Spot temperature checks
** From Irrigation District records
*** Return to Muddy Creek
**** USGS gage station records

As previously mentioned, water temperatures at the return stations were comparable to those nearby in the Sun River with the exception of the Willow Creek Reservoir Drain which increased river temperatures slightly.

Maximum turbidities of returns ranged from 250 ppm in 1973 to 1,000 JTU in 1974. Highest turbidities occurred when return flows were above normal due to seepage and excess irrigation water. Mill Coulee and Muddy Creek accounted for the highest turbidities during both years of the study. The Willow Creek Reservoir Drain (Photo 10) slightly increased turbidity of the river on several occasions. Red-colored water (Photo 11) ran into the Sun River from the Drain by Barsotti's in July of 1973. The drain was followed upstream but the cause of the colored water wasn't found. Pollution from a hog lot was found on this drain approximately one-half mile from the mouth (Photo 12) and may have contributed to the coloration of the water.

Muddy Creek added more turbidity to the Sun River than any other return. Turbidities ranged from 20 to 250 ppm in 1973 and 30 to 1,000 JTU in 1974. Muddy Creek is subjected to fluctuating flows due to varying amounts of water from tributaries and coulees that drain irrigation runoff and excess irrigation water from the Fairfield Bench. The fluctuating flows cause bank erosion on Muddy Creek and sediment is carried downstream into the Sun River. A delta of silt has developed at the mouth of Muddy Creek (Photo 13).

Measurements of total dissolved solids indicate the return stations vary from 150 to 2,500 ppm. Highest readings were noted at Big Coulee and Dobie Creek and were most apparent at low flows.

SUMMARY

A total of 42 stations on the Sun River, its tributaries and diversions, were monitered during 1973 and 1974 for flow, turbidity, total dissolved solids and temperature. USGS stations on the Sun River recorded flows of 20 to 562 cfs during 1973 and 7 to 6,990 cfs for 1974. Diversion flows from the Sun River reached a maximum of 1,537 cfs while return flows varied from no flow to 730 cfs.

Turbidity measurements from the Sun River in 1973 were quite low, although increased turbidity occurred when Gibson Reservoir was pulled to near river conditions. Runoff conditions in 1974 resulted in higher turbidities at all stations than in 1973. Mill Coulee and Muddy Creek flows contributed significantly to the turbidity of the Sun River both years.

Total dissolved solids were quite low in the Sun River, ranging from 100 to 200 ppm in the upper portions and increasing to 550 ppm below Muddy Creek. Return flows were generally higher in total dissolved solids, ranging from 300 to 2,500 ppm. Total dissolved solids were highest during periods of low flow but were diluted by irrigation water during higher flows.

Maximum temperatures of the Sun River ranged from 66°F. on the upper thermograph station to 77°F. on the lower stations. Temperatures at mouths of returns were generally comparable to those of the Sun River where they met. The only return that increased temperatures in the Sun River was the Willow Creek Reservoir Drain.

Use of bulldozers for constructing gravel and rock dikes to divert water was evident in seven out of nine diversion stations checked. This does not include the Bureau of Reclamation Diversions to the Greenfields and Fort Shaw Irrigation Districts which are of a more permanent nature.

There is up to a 50 percent loss of water due to evaporation and seepage in each of the Pishkun and Sunny Slope Canals. Several instances were noticed where ditches carried more water than their designed capacity and this may add to seepage problems. The canal from Diversion Dam to Willow Creek Reservoir has serious bank erosion on the Sun River Game Range where the gradient of the canal drops abruptly. It was also documented that several ditches crossed irrigation return or tributary streams with some or no transfer of water. These involve the Floweree Canal and School Section Coulee, Alfalfa Canal and School Section Coulee, and Sun River Valley Canal and Mill Coulee. If the return waters could be recycled, higher quality water could be left in the Sun River. Several instances were noted where water diverted for irrigation and not used was running straight through canals and emptying into a return. Dewatering of the Sun River below diversion structures wasn't too drastic during the two-year study period but could have a greater effect if the river experienced lower flows. The dewatering noticed below the Fort Shaw and Rocky Reef diversions was of short distance as accretions brought the river flow back up again. The low flows below Diversion Dam during the annual dam inspection periods probably have a greater impact on aquatic life than do low flows from any other diversions.

DISCUSSION

In a pollution study on Muddy Creek, Johnson, (1972) stated that the source of silt from Muddy Creek is in the lower reaches where the stream cuts as much as 20 feet into the streambed in a sheer face. Approximately 204,000 tons of sediments are dumped into the Sun River each year from Muddy Creek. Some of this sediment is composed of very fine colloidal silt. Sediment ponds would have little effect in removing this material. Johnson also stated that the Bureau of Reclamation admits that water use is not measured nor are farmers charged for excess water used. Consequently, Muddy Creek is carrying nearly 25 percent of the available water away as wastage. In order to bring bank erosion under control, the flow would have to be brought below 25 cfs. An alternate suggested by Johnson is a lined flume to bypass eroding banks.

In a report dated April, 1974, the Bureau of Reclamation presented information on erosion problems in Muddy Creek, along with possible solutions. This report stated that erosion of the stream channel was caused by a number of factors. Ground water levels in the Muddy Creek drainage are fed by subsurface effluent from the surrounding benchlands and are higher than the natural water level of the Muddy Creek channel. The subsoils are kept wet and cause the banks to slough into Muddy Creek during periods of high flow. Overgrazing was stated as another problem contributing to silt movement into the channel from surface runoff during periodic rainstorms. Another problem stated was the erratic flows in Muddy Creek caused by irrigation return flows from the Fairfield Bench. Several major drains discharge directly into Muddy Creek, augmenting the natural runoff during the irrigation season and further contribute to bank erosion and channel degradation.

A possible solution to the siltation problem of Muddy Creek suggested by the Bureau of Reclamation would be the construction of a dam and reservoir near Power. A recycling system would be incorporated into the project and would collect waste water from terminal wasteways and drains below the dam and would be carried into the reservoir by a collection system. The water collected would be recycled back onto the lower benches of the Greenfields Project. To reduce the sediment load into the Sun River from Muddy Creek, the release from Muddy Creek Reservoir would be zero except for discharges of spills.

Three other possible solutions were suggested in the report but the dam on Muddy Creek has the greatest potential because the major problem is the addition of waste waters from the Greenfields Project to Muddy Creek. Recycling of waste water would reduce erosion in the Muddy Creek stream channel. Also, proper management and recycling of water diverted from the Sun River would result in maintaining suitable flows for aquatic life throughout the river and further reduce waste flows to Muddy Creek.

RECOMMENDATIONS

1. Control Gibson Reservoir water levels to prevent siltation problems in the Sun River below the dam.

2. The need for annual inspections of the Diversion Dam structure should be re-examined. Reduced river flows such as 7 cfs on April 25, 1974 create harsh environmental conditions on the aquatic habitat, particularly for insects and small fish.

3. More water should flow in the Sun River below Diversion Dam prior to and after spring runoff to alleviate the excessive flows experienced during runoff (Figure 2). These flows would have to be correlated with available data from snow surveys. If flows were regulated throughout the year, a more permanent river channel would develop and permanent streambank vegetation would have a better chance of establishment.

4. Rectify erosion problems of the Willow Creek Supply Canal through the Sun River Game Range.

5. Diversion structures in the Sun River should be made more permanent to eliminate bulldozer activity in the river every spring.

6. Devise methods to prevent seepage in canals. If this could be accomplished, river flows could be stabilized. Improve manipulation of headgates to minimize wasting of water. Ditches should carry only the amount of water tney are designed for to help cut down on seepage loss.

7. Where canals cross canals and/or irrigation returns, turbid return waters should be recycled wherever possible, as is now being done in several places on the Fairfield Bench.

8. Cut down flows in diversions when not needed to minimize the amount of water diverted but not used. Examples would be after periods of heavy rain and during haying season. This would relieve excess flows in return drainages such as School Section Coulee, Big Coulee, Dobie Creek, Sun River Valley Drain, Mill Coulee and drains to Muddy Creek.

9. Urge the Bureau of Reclamation to further develop plans for stabilizing erosion of Muddy Creek.

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APPENDIX I. Photos depicting various situations in the study area.

Photo 1. Sun River downstream from Diversion Dam. Dewatered conditions relating to annual inspection of structure of Diversion Dam.

Photo 2. Drawdown of Gibson Reservoir. Mud shorelines responsible for siltation in Sun River below dam.

Photo 3. Low flow in Sun River below Fort Shaw Diversion.

Photo 4. Low flow in Sun River below Rocky Reef Diversion.

Photo 5. Normal flow in Sun River below Rocky Reef Diversion.

Photo 6. Floweree Canal over School Section Coulee at Golden Ridge.

Photo 7. Mixing of water of Alfalfa Canal (clear) with School Section Coulee (turbid).

Photo 8. Sun River Valley Canal under Mill Coulee near town of Sun River.

Photo 9. Typical private diversion showing gravel dike created by annual bulldozer activity.

Photo 10. Turbid water entering Sun River from Willow Creek Reservoir Drain. Photo also shows gravel dike for Floweree Diversion.

Photo 11. Barsotti Drain showing red-colored water entering Sun River.

Photo 12. Domestic pollution from hogs in Barsotti Drain.

Photo 13. Muddy Creek flowing into Sun River, showing silt delta.